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SURFACE SCIENCE CAPABILITIES FROM IMP SPECTRAL IMAGING. R. B. Singer and the IMP Team, Planetary Image Research Laboratory, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA.

The Imager for Mars Pathfinder (IMP) originally had a single 12-position filter wheel for one of its two "eyes." Originally eight, and then nine, of these filters were optimized for surface science, and three narrow-band filters for atmospheric science. Because of some design revisions we will now have filter wheels on both sides. The wheels for right and left eyes are identical, 12 filter positions each, and rigidly linked to the same rotation shaft. There are now 13 surface filters, in addition to 5 for atmospheric observations. Refer to Table 1 for details of all the filter positions. Figure 1 shows approximate gaussian bandpasses for the 13 surface filters.

Geologic Science: The geology or surface filters are targeted for specific science objectives, and are therefore not necessarily uniform in bandwidth or spacing. A major capability of the geology bandpasses is to differentiate (and in many cases identify) most types of crystalline ferric oxide and oxyhydroxide from each other and from poorly crystalline or nanophase ferric oxides such as found in Mars-analog palagonites [1–4]. This provides knowledge of phases indicative of different environments and modes of alteration. With high signal/noise we can also study some subtle differences due to mixtures and coatings of weathered minerals. An equally important capability is to characterize unaltered crustal material (dark materials). In most cases we can estimate pyroxene Fe^{2+} "1-µm" band positions well enough to estimate the composition and mineralogy. Most spectrally observed dark regions on Mars show pyroxene bands centered from about 0.92 to 0.98 µm [5,6]. Where Fe^{2+} band minima occur slightly longward of 1.0, however, such as for very high Ca pyroxenes as well as for olivine, we are limited by the silicon detector spectral range. If we observe any dark materials with IMP that do not display a "1-µm" band, our interpretations will have to rely on inferences based on the shape and slope of the spectrum shortward of 1.0 µm.

The original set of eight geology filters was augmented to nine last fall with the addition of a 0.48-µm filter. This improved discrimination, particularly among crystalline hematite (αFe_2O_3), crystalline goethite ($\alpha FeOOH$), and nanophase or poorly crystalline ferric oxide. This distinction is important for interpreting alteration histories, and is also a significant benefit for the magnetic properties experiment. These nine bandpasses did a good job, but still left some spectral gaps. With the current set of 13 bandpasses we have extended the short wavelength coverage to 0.40 µm, filled the most significant spectral gaps, and provided an extra channel in the important Fe^{2+} and Fe^{3+} region between 0.89 and 1.0 µm. While still not a complete spectrometer, IMP is quite powerful for determining surface mineralogy, considerably more so than Viking.

The geology filters are arranged from the violet to 0.75 µm in one eye, and from 0.75 µm to the infrared in the other. This is to avoid the risk of choppiness or jitter in spectral data that can occur when measurements from different detectors are interleaved. (Both Galileo NIMS and Phobos2 ISM have had such problems.) Because IMP has a small number of relatively broad bandpasses, it is especially important that we can trust our calibration of contiguous channels.

Overlap between the two eyes is provided at 0.75 µm, a region where Mars-like materials generally lack absorption bands and have high reflectance. This is also a region of good signal/noise and

TABLE 1. Arrangement of IMP bandpasses in the two filter wheels.

Left Eye			Right Eye		
Center (µm)	FWHM (A)	Filter Position	Center (µm)	FWHM (A)	
0.450	50	1	0.450	50	
0.890	50	2	0.890	50	Atmospheric
0.925	50	3	0.925	50	Science
0.935	50	4	0.935	50	
0.985	50	5	0.985	50	
0.75	200	6	0.75	200	Stereo
0.80	200	7	0.67	200	
0.86	300	8	0.60	200	
0.895	300	9	0.53	300	Geologic
0.93	350	10	0.48	300	Science
0.965	350	11	0.44	350	
0.99*	400	12	0.40	400	

* Actual filter center = 1.00 µm.

high spectral contrast among surface materials, and so will be used for obtaining stereo and nominal monochrome images.

Condensates: IMP is also sensitive to condensates on the surface. There are striking differences in both albedo and color between frost and martian soils and rocks, making IMP sensitive to even thin or patchy condensate deposits. This is true for both H_2O and CO_2 frosts. Shortward of 1 µm the strongest H_2O ice band is an overtone centered near 0.95 µm. This band can vary in depth from as much as 10% for coarse-grained frost (400–2000 µm) to as little as 2% for fine-grained frost (50 µm) [7]. This water ice band is broad enough that for an optically thick frost layer it should be detectable

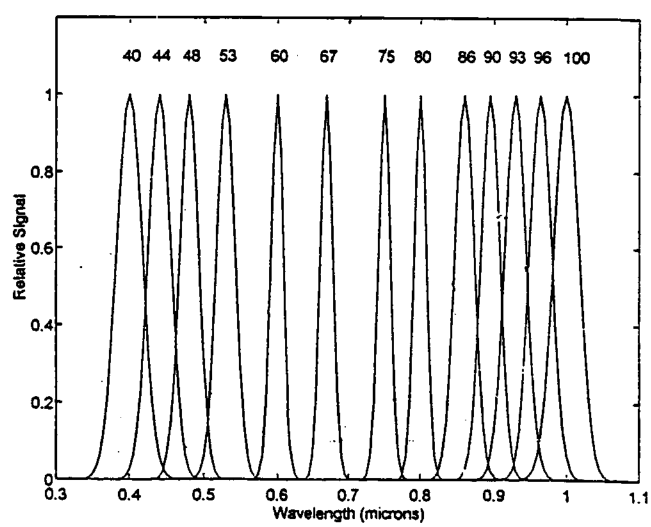

Fig. 1. The 13 surface science bandpasses shown as normalized gaussians. Actual sensitivity of each bandpass will depend on peak filter transmission, solar spectrum, and CCD responsivity.

and well defined by the five bandpasses from 0.86 to 1.0 μm. For an optically thin frost layer the 0.95-μm band can be difficult to see, depending on the substrate, even though the effect on visual slope and albedo is still large [8].

True Color Imaging: Accurate visual color rendition is important to the mission, for public distribution as well as science. Human color vision is a complicated and apparently not fully understood topic. After extensive research we have concluded that there is no single set of three bandpasses that is accepted as "best" at reproducing the colors that most people see most of the time. (MIPS at JPL has apparently reached a similar conclusion.) One common published system uses primaries of 436, 546, and 700 nm [e.g., 9], while another standardizes on 444, 526, and 645 nm [10]. We propose to use the IMP bandpasses at 440, 530, and 670 nm for standard "true color" imaging.

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GOLDSTONE RADAR CONTRIBUTIONS TO MARS PATHFINDER LANDING SAFETY. M. A. Slade and R. F. Jurgens, Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109-8099, USA.

Goldstone radar can provide topography "profiles," statistical surface roughness, and radar images within a few degrees of the sub-Earth point. Goldstone/Very Large Array (VLA) bistatic radar observations can image the whole disk of Mars with integration times on the order of 10 min before pixel smearing occurs. Data from all these radar techniques can be useful for observing the local surface conditions relating to landing safety issues for Mars Pathfinder. Topographic profiles will be presented from the 1978 opposition (subradar latitude ~10°N), and the 1980–1982 oppositions (subradar latitudes ~20°–22°N) at 13 cm wavelength with a radar "footprint" of ~8 km (longitude) by 80 km (latitude). The 1992–1993 opposition (subradar latitudes ~4°–10°N) has both Goldstone/VLA images and topographic profiles at 3.5 cm wavelength (many of the latter have yet to be reduced).

During the 1995 opposition, additional opportunities exist for obtaining the data types described above at latitudes between 17°N to 22°N (see Fig. 1). Upgrades to the radar system at Goldstone since 1982 will permit higher accuracy for the same distance with a reduced footprint size at 3.5 cm. Since the Arecibo radar will still be in the midst of their upgrade for this upcoming opposition (which starts ~November 1994, with closest approach in February 1995), the Goldstone radar will be the only source of refined radar landing site information before the Mars Pathfinder landing.

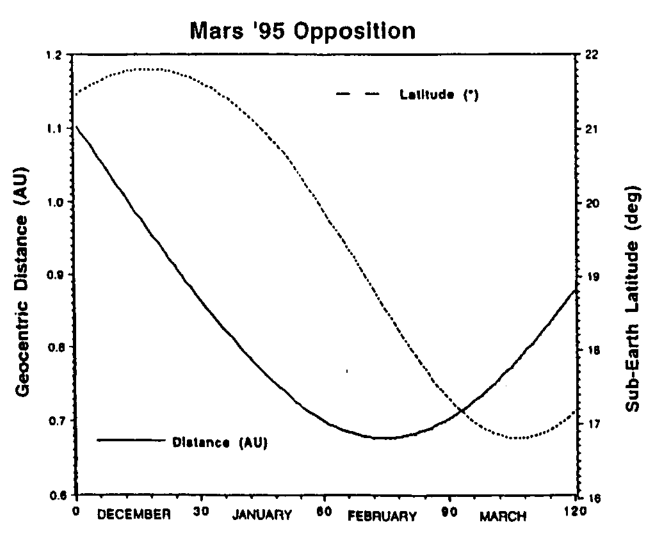

Fig. 1.

N95-16206

IMAGER FOR MARS PATHFINDER (IMP). P. H. Smith, Lunar and Planetary Laboratory, University of Arizona, Tucson AZ 85721, USA.

The IMP camera is a near-surface remote sensing experiment with many capabilities beyond those normally associated with an imager. The camera is fully pointable in both elevation and azimuth with a protected, stowed position looking straight down. Stereo separation is provided with two (left and right) optical paths; each path has a 12-position filter wheel. The two light paths converge onto a single CCD detector that divides its 512 × 256 active pixels evenly between them. The CCD is a frame transfer device that can transfer a frame in 0.5 ms, avoiding the need for a shutter. Because the detector has a high quantum efficiency (QE) and our filters are relatively broad (40 nm FWHM), the camera optics are stopped down to f/18, giving a large depth of field; objects between 0.6 m and infinity are in focus, no active focusing is available. A jack-in-the-box mast elevates the camera about 75 cm above its stowed position on top of the lander electronics housing; the camera is fully functional in its stowed position so that pictures taken of the same object in each position can be compared to give accurate ranging information. The camera is designed, built, and tested at Martin Marietta. Laboratory testing of flightlike CCDs has been done at the Max-Planck-Institut für Aeronomie in Lindau, Germany, under the direction of co-investigator Dr. H. Uwe Keller, who is providing the focal plane array, the pre-amp board, and the CCD readout electronics with a 12-bit ADC. The important specifications for the IMP camera from the point of view of the scientists using the camera are given in Table 1. For comparison the same quantities are also provided from the Viking camera system.

Science Objectives: The primary function of the camera, strongly tied to mission success, is to take a color panorama of the surrounding terrain. IMP requires approximately 120 images to give a complete downward hemisphere from the deployed position. The local horizon would be about 3 km away on a flat plain, so that one can hope to have some information over a 28 km^2 area. At the horizon a pixel covers 3 m, but the resolution improves at closer distances; just outside the lander edge a pixel is 1.6 mm. Therefore,